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Relation of the Total Nitrogen of the Soil to its Needs as Shown in Pot Experiments

BY
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RELATION OF THE TOTAL NITROGEN OF THE SOIL TO ITS NEEDS AS SHOWN IN POT EXPERIMENTS.

By G. S. Fraps, *Chemist.*

It is a well known fact that the quantity of nitrogen which can be taken up from the soil by crops depends, to a considerable extent, upon other factors than the total nitrogen of soil. The term "active nitrogen" is used to designate the nitrogenous compounds which can be taken up by plants—ammonia, nitrates, and certain organic compounds. It has been shown, for example, in a previous bulletin of this station (Bulletin No. 106, July, 1908) that the production of active nitrogen in the soil depends to a certain extent upon the total nitrogen of the soil, the nature of the soil, the quantity of water contained therein, and the nature of the organic nitrogenous compounds. It was also shown in the bulletin referred to, that the quantity of active nitrogen produced was related to the growth of the crops in pot experiments, and to the quantity of nitrogen contained therein.

It can not be expected, therefore, that the total nitrogen content of the soil would be strictly related to the needs of the soil for nitrogen in pot experiments. Nevertheless, we consider it of importance to study this phase of the question, both for its own object, and also as a basis for further work on the nitrogen of the soil.

METHOD OF WORK.

The method of pot experiments is as described in Bulletins 127 and 145 of this station. In all cases, pots receiving phosphoric acid, potash and nitrogen, are compared with those receiving phosphoric acid and potash only. The total number of crops considered is 332.

The details of the individual experiments are similar to those given in the bulletins referred to above, and are presented in table 4.

RELATION OF TOTAL NITROGEN TO NUMBER OF DEFICIENT CROPS.

We term a crop *very deficient* (DD) when the crop without nitrogen is 50 per cent. or less of that with nitrogen. If the crop without nitrogen is 50 to 90 per cent. of that with nitrogen, it is termed *deficient* (D). If the crop without nitrogen is 90 per cent. or more of that with nitrogen, it is termed *sufficient* (S).

Table 1 shows the number of crops very deficient DD, deficient D, and sufficient S, grown in the soils and arranged according to the soil content of total nitrogen, and also the percentages of such crops, calculated from the total number in each group.

TABLE 1.—NUMBER OF DEFICIENT CROPS IN GROUPS ARRANGED ACCORDING TO TOTAL NITROGEN OF SOIL.

	Number of crops.			Percentage of crops.		
	DD	D	S	DD	D	S
0—.02	12	1	2	80	7	13
0.021—0.04	38	31	6	51	41	8
0.041—0.06	31	39	13	37	47	16
0.061—0.08	11	18	1	36	60	4
0.081—0.10	12	18	11	29	44	27
0.101—0.12	7	14	9	23	47	30
0.121—0.14	7	10	4	33	48	19
0.141—0.16	6	3	3	50	25	25
0.161—0.18	1	3	3	20	60	60
0.181—0.20	1	5	2	12	64	29
0.201—0.22			1			
0.221—0.29	1	5	2	12	64	29

DD—Very deficient. D—Deficient. S—Not deficient.

There is a general relation between the percentages of crops very deficient or sufficient, and the nitrogen content of the soil. The percentage of very deficient crops decreases somewhat irregularly from 80 per cent. in the soil containing .02 per cent. nitrogen or less, to 12 per cent. in the crops containing 0.22 per cent. nitrogen or more. The percentage of sufficient crops is much more irregular, but there is a tendency to increase with the percentage of nitrogen in the soil.

Examination of the individual experiments discloses the fact that the deficiency is related in a general way to the total growth of the crop.

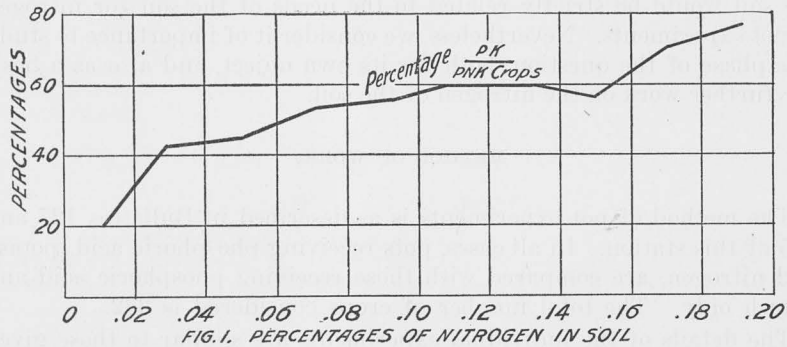

Fig. 1.—Ratio of crops without nitrogen to crop with nitrogen.

TABLE 2.—AVERAGE WEIGHT OF ALL CROPS WITH AND WITHOUT NITROGEN ARRANGED ACCORDING TO NITROGEN CONTENT OF SOIL.

	Average weight.		Ratio PK / PNK	Number of crops	Maximum weight
	PK Grm.	PNK Grm.			
0—.02%	3.4	17.1	20	15	7.0
.021—.04%	6.1	14.6	42	79	20.0
.041—.06%	8.1	18.9	43	76	25.8
.061—.08%	11.0	20.8	53	30	39.2
.081—.10%	10.3	18.1	57	42	33.0
.101—.12%	11.0	18.0	61	32	30.0
.121—.14%	11.1	18.3	61	21	31.5
.141—.16%	14.1	24.8	57	12	32.6
.161—.18%	11.7	16.9	69	8	19.0
.181—.20%	14.2	18.8	76	8	37.5
.201—.22%				1	
.221— %	17.8	24.6	72	8	47.8
Total				332	

As a general rule, the larger the crop with complete fertilizer, the greater the probability of the soil being very deficient or deficient.

RELATION OF THE NITROGEN TO WEIGHT OF CROPS.

Table 2 brings out the relation of the total nitrogen to the average weights of the crops grown with and without nitrogen. The average weight of the crop without nitrogen increases with the nitrogen-content of the soil. The soils can be combined into a smaller number of groups, as follows:

Nitrogen in soil.	Average weight (Without Nitrogen).
0—.02 per cent Nitrogen	3.4
0.021—.04 per cent Nitrogen	6.1
0.41 —.06 per cent Nitrogen	8.1
0.061—.18 per cent Nitrogen	11.0—14.1
.181—20 per cent Nitrogen	14.2
.221— per cent Nitrogen	17.8

Thus the weight of the crop increases with the nitrogen of the soil up to .06 per cent. nitrogen, and remains nearly the same for the groups .06—.18 per cent. This is shown graphically in Fig. 2.

The total nitrogen of the soil is of greater significance in pot experiments below .06 per cent. than it is above that quantity, so far as total average weight of the crops are concerned.

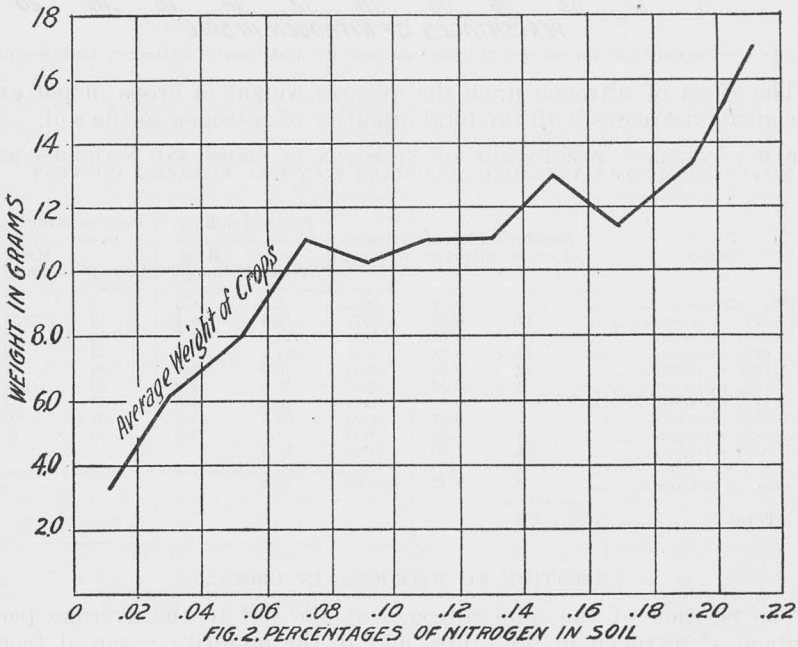

Fig. 2.—Relation of the average weight of the crop to the nitrogen content of the soil on which it was grown.

The ratio of the crop without nitrogen, to that with nitrogen, expressed in percentages, is given in Table 2, and shown graphically in

Figure 1. This decreases quite regularly with the nitrogen content of the soil. That is to say, the effect of fertilizer nitrogen in pot experiments decreases with the increase in the nitrogen content of the soil. For example, the addition of nitrogen to soils containing less than .02 per cent nitrogen, increases the crop to five times as great. With soils containing .021—.04 per cent, nitrogen, addition of nitrogen causes the crop to be nearly two and one-half times as great. The addition of nitrogen to the soils containing about 0.22 per cent. nitrogen, increases the crop about one-third. This is shown in Figure 1-A. The distance between the upper and lower lines represents the effect of the added nitrogen, and it is readily seen that the effect of the nitrogen decreases as the nitrogen in the soil increases.

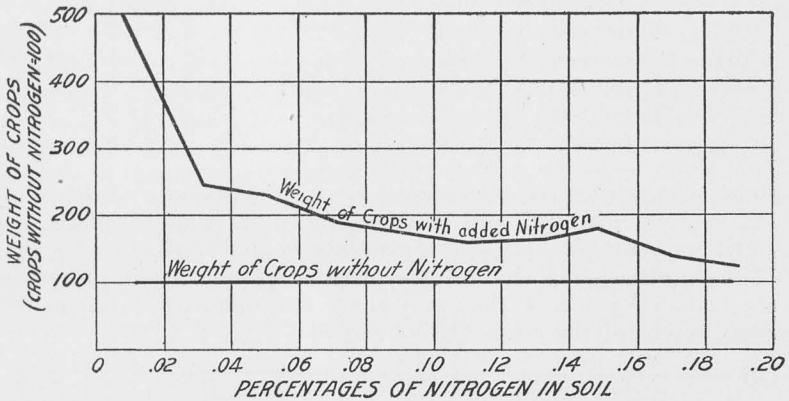

Fig. 1-A.—Percentage increases in crops caused by addition of nitrogen to the soil.

The effect of nitrogen upon the average weight of crops in pot experiments decreases with the total quantity of nitrogen in the soil.

TABLE 3.—AVERAGE PERCENTAGE OF NITROGEN IN CROPS AND NITROGEN REMOVED FROM SOILS ARRANGED ACCORDING TO TOTAL NITROGEN CONTENT.

Group.	Number of crops.	Percent nitrogen.	Grams nitrogen.	Parts of million.		Corn possibility.	
				Average.	Maximum.	Average.	Maximum.
0—.02% nitrogen	9	0.62	.0284	5.7	8.3	8	11
.021—.04% nitrogen	17	0.56	.0471	9.4	26.4	12	35
.041—.06% nitrogen	27	0.63	.0681	13.6	31.7	18	42
.061—.08% nitrogen	13	0.78	.1207	24.1	74.0	32	98
.081—.10% nitrogen	12	0.81	.0995	19.9	48.0	26	64
.101—.12% nitrogen	5	0.57	.0991	19.8	33.0	26	44
.121—.14% nitrogen	9	0.85	.1404	28.1	64.0	37	85
.141—.16% nitrogen	7	0.81	.1183	23.7	45.3	31	60
.161—.18% nitrogen	3	1.08	.2145	42.9	55.0	56	73
.181—.20% nitrogen	1	1.39	.4170	83.4			
.201—.22% nitrogen	0						
.221—up of nitrogen	2	1.17	29.95	59.9			
Total	105						

RELATION TO NITROGEN IN CROPS..

The relation of the total nitrogen of the soil to the average percentage of nitrogen in the crops, and to the quantity removed from the soil, is shown in Table 3, and graphically in Figure 3.

The average nitrogen content of the crops increases with the average nitrogen content of the soil. It would have been better, however, had

a larger number of crops in each group been subjected to analysis. Work along this line is being continued.

The average nitrogen removed from the soil increases with the average nitrogen content of the soil, though somewhat unequally.

The nitrogen removed from the soil has also been calculated to bushels of corn per acre. It is assumed that a bushel of corn requires 1.5 lbs. nitrogen for grain, leaves and stalk, and that the plant can draw upon the soil to the depth of about 8 inches, such depth of soil weighing two million pounds per acre.

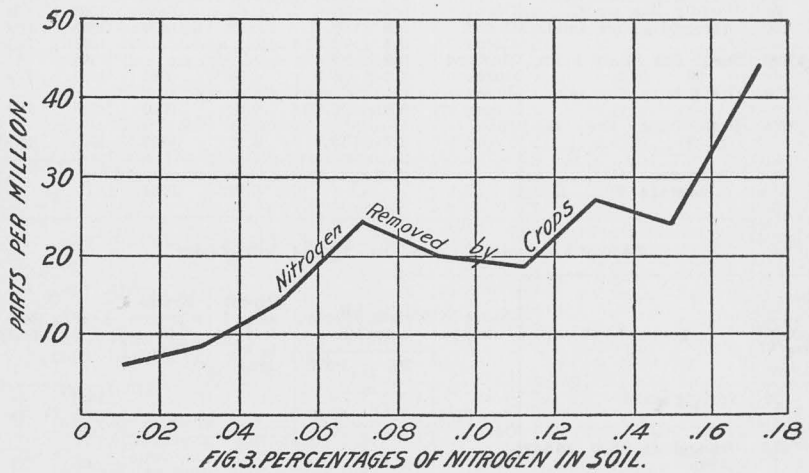

Fig. 3.—Relation of the amount of nitrogen removed by the crop to the nitrogen content of the soil.

The nitrogen withdrawn by the crops in the pot experiments, expressed as bushels of corn, increases from 8 bushels per acre for soils containing less than .02 per cent. nitrogen, to 56 bushels per acre for soils containing 0.16—0.18 per cent. nitrogen. The maximum corn possibility is more irregular than the average. These calculations do not take into consideration the nitrogen in the roots of the plants, or that contained in the seed planted in the pots.

RELATIVE DEFICIENCY.

We must here emphasize the fact brought out in Bulletin 145, that deficiency is relative, and that the composition of the soil and the results of the pot experiments must be considered in connection with the known field possibilities of the soil. If the nitrogen is not sufficient for the maximum crop possible under the soil condition, then the soil will appear deficient, but even small quantities of nitrogen may be sufficient for soils located under relatively unfavorable conditions. This matter will be discussed in detail in future bulletins, when application is made of the results of the work on the active phosphoric acid, active potash, and total nitrogen of the soil.

ACKNOWLEDGMENT.

Assistance in the analytical and other work involved in the preparation of this bulletin has been rendered by Messrs. Rather, Asbury, Kelly, Ogier, Carlyle, Herron and possibly other assistant chemists.

TABLE 4.—Group 1. 0—.02%, TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
819	Norfolk fine sandy loam	Corn	4.8	18.2	0.66	0.0317	1907	DD
		Wheat	2.5	1.9			1908	S
		Corn	2.9	21.1	0.43	.025	1908	DD
821	Orange fine sand	Corn	2.6	10.8			1907	DD
		Corn	0.4	5.0			1907	DD
		Corn	2.9	7.2	0.45	.0130	1908	DD
		Mustard	1.0	1.5			1908	D
828	Norfolk fine sand	Corn	3.6	19.2	0.98	.0353	1907	DD
859	Norfolk fine sand	Corn	6.7	29.8	0.62	.0415	1908	DD
860	Orangeburg fine sand	Corn	5.8	36.1	0.69	.0400	1907	DD
		Corn	0.4	2.5			1908	DD
2350	Susq. fine sandy loam	Mustard	3.0	2.9			1909	S
		Corn	7.0	48.0	0.55	.0385	1910	DD
3654	Orangeburg fine sand	June corn	5.0	22.5	0.62	.0310	1910	DD
3655	Orangeburg fine sand S. S.	June corn	2.2	29.5	0.56	.0123	1910	DD
	Average (15)		3.39	17.08				
	Average (9)				0.62	.0284		

TABLE 4.—Group 2. 0.02—.04, TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
172	Norfolk sand	Corn	7.2	9.7			1906	D
		Cow peas	7.5	10.2			1906	D
		Oats	5.0	6.0			1906	D
310	Orangeburg fine sandy loam	Corn	5.4	6.1			1906	D
		Cow peas	4.1	4.0			1906	S
		Oats	4.1	5.0			1906	D
316	Norfolk fine sandy loam	Corn	6.9	12.1			1906	D
		Cow peas	5.3	7.7			1906	D
		Oats	4.5	7.0			1906	D
318	Lufkin fine sand	Corn	3.2	4.9			1906	D
		Cow peas	2.0	2.6			1906	D
		Oats	5.9	6.9			1906	D
820	Susq. fine sandy loam	Corn	5.6	12.5			1907	DD
822	Lufkin fine sandy loam	Corn	21.0	20.6			1907	.08% in bulk.
911	Norfolk fine sand	Grass	1.4	2.5			1908	D
913	Susq. fine sandy loam	Corn	6.0	6.4			1907	S
936	Barton sandy loam	Corn					1907	
		Wheat	0.7	1.6			1908	DD
		Corn	4.8	11.3			1908	DD
		Sorghum	8.5	12.7			1909	D
937	Orangeburg fine sandy loam	Corn	6.4	8.4			1907	D
1120	Susq. fine sand S.S.	Corn	4.0	13.0	.62	.0248	1908	DD
		Mustard	4.9	5.1			1908	S
		Sorghum	8.5	27.3			1909	DD
1125	Winfield fine sand	Corn	13.9	32.0			1908	DD
		Mustard	1.2	3.5			1909	DD
		Sorghum	5.9	29.8			1909	DD
1126	Winfield fine sand S. S.	Corn	11.0	26.2	0.50	.055	1908	DD
		Sorghum	4.8	17.5			1909	DD
1130	Lufkin silt loam S.S.	Corn	16.6	29.0	0.59	.0979	1908	D
1134	Norfolk fine sand S.S.	Corn	9.6	29.4	0.50	.0480	1908	DD
		Mustard	1.0	6.6			1908	DD
1136	Norfolk fine sandy loam S.S.	Corn	7.2	23.0			1908	DD
1200	Nueces fine sand	Corn	5.0	16.0	0.53	.026	1908	DD
		Mustard	2.1	7.4			1908	DD
1207	Nueces fine sandy loam	Corn	20.0	26.0	0.66	.1320	1908	D
		Mustard	1.6	6.4			1909	DD
		Sorghum	17.9	16.6			1909	S
1577	San Antonio clay loam	Mustard	9.7	11.9			1908	D
		Sorghum	15.9	15.7			1909	S
		Kaffir	2.9	4.1			1909	D
1579	Norfolk silt loam	Mustard	8.8	10.2			1908	D

TABLE 4.—Group 2—continued.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
		Corn	10.4	21.3			1909	DD
1585	Willis sand S.S.	Mustard	5.1	9.7			1908	D
		Sorghum	8.2	17.8			1909	DD
1586	San Jacinto clay	Mustard	5.9	10.2			1908	D
1588	Lufkin sandy loam	Mustard	4.9	8.7			1908	D
1589	Lufkin sandy loam	Mustard	1.2	5.1			1908	DD
1590	Deep S.S. to 1588	Mustard	.05	4.2			1908	DD
1591	Lufkin sand	Mustard	4.3	7.5			1908	D
1592	Lufkin sand S. S.	Mustard	2.0	6.9			1908	DD
1596	Austin clay S.S.	Mustard	2.9	4.0			1908	D
1598	Yazoo sandy loam S.S.	Mustard	3.3	9.0			1908	DD
2347	Susq. gravelly loam S.S.	Mustard	2.3	3.0			1909	D
		Corn	10.0	25.2	0.49	.049	1910	DD
2348	Norfolk fine sandy loam	Mustard	1.6	2.3			1909	D
		Corn	12.0	33.0	0.49	.0588	1910	DD
2351	Susq. fine sandy loam	Corn or oats	8.5	15.0	0.63	.0535	1910	D
		Mustard	2.2	3.9			1910	D
2352	Norfolk fine sand	Mustard	3.5	6.8			1910	D
		Corn	8.0	36.5	0.58	.0466	1910	DD
		Mustard	0.8	0.8			1910	S
		Corn	11.8	36.6			1911	DD
2353	Norfolk fine sand S. S.	Mustard	1.9	1.6			1909	D
		Corn	3.7	26.6			1910	DD
		Sorghum	3.2	29.4	0.55	.0176	1910	DD
3331	Travis gravel	Sorghum	10.7	50.4	0.43	.0460	1910	DD
		Mustard	2.0	5.5			1910	DD
		Corn	5.4	50.8	0.48	.0259	1911	DD
3346	Susq. fine sandy loam	Sorghum	6.6	40.5	0.52	.0341	1910	DD
3975	Lufkin fine sandy loam S. S. to 3974	Oats	3.0	11.2			1910	DD
3976	Lufkin clay	Oats	8.1	13.0			1910	D
		Corn	4.2	31.8	0.56	.0235	1911	DD
4644	Poor upland	Corn	19.2	47.7			1911	DD
3656	Orangeburg fine sandy loam	June corn	6.2	20.4	0.67	.0415	1910	DD
3657	Orangeburg fine sandy loam S.S.	June corn	3.0	17.9	0.66	.0198	1910	DD
	Average		6.13	13.35				
	Average (17)				0.56	.0471		

TABLE 4.—Group 3. 0.041—.06 TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
314	Norfolk fine sand	Corn	11.9	10.7			1906	S
		Cow peas	6.5	9.4			1906	D
		Oats	5.8	4.5			1906	D
340	Susq. sandy loam	Corn	7.0	12.0			1906	D
		Oats	3.0	4.0			1906	D
		Mustard	1.0	0.1			1908	S
		Sorghum	1.6	1.1			1909	S
342	Orangeburg fine sand	Corn	1.8	2.0			1906	S
		Oats	12.0	10.5			1907	S
344	Orangeburg fine sandy loam	Oats	3.0	4.0			1906	S
816	Laredo fine sand	Corn	13.0	16.2	1.04	.1352	1907	D
		Corn	4.0	3.4	1.63	.0424	1907	S
		Grass	2.8	6.2			1908	D
		Mustard	6.5	10.8			1908	D
827	Laredo silt loam	Corn	9.8	15.5	0.71	.0695	1907	D
		Corn	2.2	2.9			1907	D
		Grass	2.9	3.5			1908	D
		Mustard	7.8	7.5			1908	S
		Sorghum	8.1	13.3			1909	D
850	Susq. sandy loam	Corn	2.2	18.0	0.74	.0162	1908	DD
914	Lufkin fine sandy loam	Corn	4.4	10.9			1907	DD
		Grass	3.1	3.8			1908	D
976	Surface soil	Mustard	2.6	7.6			1908	DD
1119	Susq. fine sand	Corn	5.5	35.6			1908	DD

TABLE 4.—Group 3—continued.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
		Mustard	5.2	6.9			1908	D
		Sorghum	7.6	25.95			1909	DD
1124	Winfield fine sand loam S.S.	Corn	23.7	21.0	0.54	.1279	1908-10	S
		Mustard	5.1	4.6			1908	S
1129	Lufkin silt loam	Corn	25.8	36.5	0.51	.1472	1908	D
1133	Norfolk fine sand	Corn	12.0	15.9	0.59	.0708	1908	D
		Mustard	2.0	5.0			1908	DD
		Sorghum	5.9	26.0			1909	DD
1138	Susq. fine sandy loam S. S.	Corn	12.0	20.2	0.62	.0744	1908	D
		Sorghum	6.6	18.5			1909	DD
1139	Lufkin fine sandy loam	Corn	23.1	44.0	0.53	.1246	1908	D
		Mustard	4.4	4.4			1909	S
		Sorghum	10.5	28.3			1909	DD
1140	Lufkin fine sandy loam	Corn	21.0	45.5			1908	DD
1203	Houston clay S.S.	Corn	22.0	29.7	0.74	.1584	1908	D
		Mustard	4.0	6.8			1909	D
1205	Houston loam S.S.	Corn	7.0	16.0	0.84	.0588	1908	DD
		Mustard	6.5	10.2			1909	D
1206	Nueces fine sandy loam	Corn	11.5	17.5	0.54	.0621	1908	D
1578	San Antonio clay loam S.S.	Mustard	5.5	9.7			1908	D
1587	San Jacinto clay S.S.	Mustard	5.0	9.3			1909	D
1597	Yazoo sandy loam	Mustard	4.9	10.4			1908	DD
1926	Yazoo sandy loam	Corn	13.4	10.8			1909	S
1934	S.S. to 1931	Corn	15.8	22.6			1909	D
2824	Orangeburg fine sandy loam	Corn	4.1	38.5	0.61	.0244	1910	DD
3332	Travis gravel	Sorghum	14.5	50.5	0.51	.0740	1910	DD
		Mustard	4.6	2.7			1910	S
		Corn	21.9	46.8			1911	DD
3337	Miller fine sandy loam	June corn	11.0	24.7	0.51	.0627	1910	DD
3339	Crawford loam	Sorghum	17.2	60.5	0.43	.0740	1910	DD
		Mustard	1.4	4.4			1910	DD
		Corn	11.3	42.0	0.43	.0486	1911	DD
3340	Crawford loam	Sorghum	16.5	62.6	0.40	.0660	1910	DD
		Mustard	0.5	2.4			1910	DD
		Corn	7.4	50.3	0.56	.0414	1911	DD
3345	Susq. fine sandy loam	Sorghum	17.9	55.5	0.48	.0859	1910	DD
		Mustard	0.7	1.5			1910	D
		Corn	8.2	48.2	0.56	.0459	1911	DD
3631	Lufkin fine sandy loam	Sorghum	15.2	50.9	0.42	.0638	1910	DD
		Mustard	2.7	4.8			1910	D
		Corn	7.5	37.2	0.55	.0413	1911	DD
3633	Houston black clay	Sorghum	3.5	18.1	0.74	.0259	1910	DD
3634	Houston black clay S.S. to 3633	Sorghum	3.0	10.2	0.97	.0281	1910	DD
		Mustard	3.3	4.1			1910	D
3974	Lufkin fine sandy loam	Oats	6.3	12.5			1910	D
		Corn	6.6	40.5	0.66	.0436	1911	DD
3977	Norfolk sandy loam	Oats	7.9	14.6			1910	D
		Corn	4.6	27.7	0.54	.0248	1911	DD
4603	Good upland	Corn	24.2	61.6			1911	DD
	Average		8.11	18.86	0.63	.0681		

TABLE 4.—Group 4. .061—.08% TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
817	Lufkin fine sandy loam	Corn	14.8	30.1	0.77	.1030	1907	DD
		Corn	2.9	3.4	1.51	.0435	1907	D
		Grass	1.2	2.9			1908	DD
818	Sanders loam	Corn	39.2	47.1	0.93	.3697	1908	D
		Corn	2.7	5.1			1908	D
832	Orangeburg fine sandy loam	Corn	20.2	26.2	1.42	.2868	1907	D

TABLE 4.—Group 4—continued.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
		Corn	0.7	1.4			1908	D
932	Miller silt loam	Corn	4.0	6.2			1907	D
		Grass	3.3	6.7			1908	D
982	Cameron clay S. S.	Corn	30.4	50.9	0.57	.1710	1908	D
		Mustard	5.1	8.1			1908	D
		Sorghum	22.7	26.5			1909	D
1123	Winfield fine sandy loam	Corn	17.0	25.8	0.87	.1044	1908-09	DD
		Mustard	6.8	9.6			1908	D
		Sorghum	28.7	33.7			1909	D
1594	Houston black clay S. S.	Mustard	4.9	11.3			1908	DD
		Sorghum	8.1	22.7			1909	DD
1600	Houston black clay S.S.	Mustard	6.9	11.1			1908	D
		Sorghum	14.4	27.9			1909	D
2341	Franklin clay S.S.	Mustard	2.8	4.0			1909	D
		Corn	18.0	37.0	0.52	.0936	1910	D
		Sorghum	2.1	28.9			1910	DD
2346	Susq. gravelly loam	Corn	25.0	45.6	0.50	.1250	1910	D
2829	Denison clay	Corn	14.0	16.5	0.66	.0924	1910	D
		June corn	3.5	11.7	0.94	.0329	1910	DD
2957	S.S. to 2956	Mustard	5.1	5.3			1909	S
		Corn	7.0	28.0	0.46	.0322	1910	DD
3632	Lufkin sandy loam	Sorghum	17.9	45.3	0.43	.0770	1910	DD
		Mustard	0.7	2.2			1910	DD
		Corn	6.1	43.3	0.59	.0370	1911	DD
	Average		11.04	20.81				
	Average (13)				0.78	.1207		

TABLE 4.—Group 5. 0.081—.10% TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
133	Sanders loam	Corn	9.7	11.9			1906	D
		Oats	10.2	10.2			1906	S
336	Susq. fine sandy loam	Corn	7.5	20.1			1906	DD
831	Laredo silty clay	Corn	26.3	60.0	0.55	.1447	1907	DD
		Wheat	1.8	1.9			1908	S
		Corn	14.0	46.9			1908	DD
833	Laredo fine sandy loam	Corn	21.4	29.0	1.12	23.97	1907	D
		Corn	5.6	2.2			1908	S
		Grass	2.8	5.9			1908	DD
834	Orangeburg fine sandy loam	Corn	4.1	24.6	0.93	.0372	1908	DD
893	Lufkin clay	Mustard	4.5	1.3			1908	S
938	Austin fine sandy loam	Corn	4.5	8.8	2.66	.1197	1907	D
		Wheat	3.2	3.0			1908	S
		Corn	15.1	40.4	0.47	.0709	1908	DD
		Mustard	5.7	6.5			1908	D
		Sorghum	10.6	10.7			1909	S
940	Wilson loam	Corn	9.8	6.7			1907	D
		Grass	3.8	5.0			1908	D
		Mustard	6.1	10.1			1908	D
		Sorghum	11.3	10.0			1909	S
1202	Houston clay, probably Victoria loam	Corn	33.0	36.3	0.51	.1683	1908	D
1202	Houston clay, probably Victoria loam	Corn	16.0	14.4	0.51	.0816	1908	S
		Mustard	5.6	7.7			1909	D
1581	Houston black clay loam S.S.	Mustard	5.3	9.9			1908	D
1582	Houston gravelly clay	Mustard	5.7	9.9			1908	D
		Sorghum	14.8	27.0			1909	D
		Kaffir	3.2	16.1			1909	DD
1583	Houston gravelling clay S.S.	Mustard	3.9	7.2			1908	D
1593	Houston black clay	Mustard	6.3	12.0			1908	D
1595	Austin clay	Mustard	5.8	9.9			1908	D
1928	S.S. to 1927	Corn	18.8	7.6			1909	S
		Sorghum	7.6	23.7			1909	DD
		Mustard	3.8	5.7			1909	D

TABLE 4.—Group 5—continued.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
1931	Calcasieu fine sandy loam	Corn	30.0	20.5			1909	S
		Sorghum	22.5	32.9			1909	D
1934	Sharkey clay S. S.	Corn	19.1	29.1			1909	D
2342	Lufkin fine sandy loam.	Corn	15.0	50.0	0.53	.0795	1910	DD
		Sorghum	7.0	40.9	0.58	.0406	1910	DD
2343	Lufkin fine sandy loam S. S.	Corn	19.5	40.5	0.65	.1268	1910	S
2826	Sherman fine sandy loam	Corn	6.5	48.5	0.56	.0464	1910	DD
		Corn	6.2	29.4	0.63	.0391	1910	DD
	Average		10.33	18.08				
	Average (12)				0.81	.0995		

TABLE 4.—Group 6. 0.101—.12% TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
910	Houston black clay	Mustard	6.2	8.2			1908	D
		Sorghum	18.1	22.1			1908	D
912	Bastrop sandy loam	Corn	5.2	4.2			1907	S
		Corn	28.5	47.7			1908	D
933	Bastrop clay	Corn	6.3	3.1			1907	S
		Grass	4.9	5.5			1908	D
		Mustard	5.3	15.9			1908	DD
		Sorghum	15.4	22.5			1909	D
934	Wabash clay	Corn	10.7	5.6			1907	S
		Grass	2.7	5.1			1908	S
		Mustard	3.1	11.7			1908	DD
935	Lufkin clay	Corn	12.5	4.5			1907	S
		Grass	4.9	2.9			1908	S
		Mustard	11.7	0.1			1908	S
		Sorghum	26.3	15.0			1909	S
941	Houston loam	Corn	10.7	13.2			1907	D
		Grass	3.7	7.0			1908	D
		Mustard	3.7	9.7			1908	DD
1121	Hagensport loam	Corn	30.0	48.7	0.55	.1650	1908	D
		Mustard	1.9	2.6			1908	D
		Sorghum		32.2			1909	
1122	Hagensport loam	Corn	18.0	24.3			1908	D
1127	Houston clay	Corn	27.8	39.3			1908	D
1580	Houston black clay loam	Mustard	6.2	11.0			1908	D
1599	Houston black clay	Mustard	4.8	13.0			1908	DD
2830	Denison clay loam	Corn	20.0	45.5	0.52	.1140	1910	DD
3335	Houston black clay	Oats	5.5				1910	
		Corn	11.0	35.3	0.49	.0539	1911	DD
3663	Orangeburg clay	June corn	15.4	20.2	0.69	.1063	1910	D
		Mustard	1.0	3.3			1910	DD
		Corn	9.7	47.9	0.58	.0563	1911	DD
2956	Orangeburg clay	Mustard	4.5	5.0			1909	S
		Corn	15.0	43.0			1910	DD
	Average		10.96	17.98				
	Average (5)				0.57	.0991		

TABLE 4.—Group 7. 0.121—.14% TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
324	Houston black clay	Corn	10.2	16.1			1908	D
		Oats	10.0	2.5			1907	S
338	Wabash clay	Corn	7.0	12.0			1906	D
		Oats	6.0	5.9			1907	S
829	Houston loam	Corn	23.8	31.4	.80	.1906	1907	D
		Corn	4.0	5.0	1.34	.0536	1907	D
		Grass	2.9	7.2			1908	DD
830	Laredo gravelly loam	Corn	17.2	5.0	1.86	.3199	1908	S
939	Houston black clay	Corn	5.2	6.5			1907	D
		Grass	3.3	3,3			1908	S
		Mustard	7.2	13.2			1908	D
		Sorghum	19.1	28.4			1909	D
2410	Subsoil to 2409	Mustard	1.1	4.2			1909	DD
		Corn	31.5	36.0	.83	.2615	1910	D
2831	Denison clay loam	Mustard	2.2	2.8			1909	D
		Corn	15.0	42.0	.48	.072	1910	DD
2944	Houston black clay loam	Corn	13.0	43.0	.51	.0663	1910	DD
		Sorghum	8.0	44.7	.57	.0456	1910	DD
3662	Orangeburg clay	June corn	31.3	24.5	.74	.1576	1910	D
		Mustard	1.7	5.1			1910	DD
		Corn	12.8	49.3	.52	.0966	1911	DD
	Average		11.08	18.29				
	Average (9)				.85	.1404		

TABLE 4.—Group 8. 0.141—.16% TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
1925	Yazoo sandy loam	Corn	32.6	43.8			1909	D
2340	Franklin clay	Mustard	3.0	1.5			1909	S
		Corn	23.5	41.5	.57	.1340	1910	D
		Sorghum	10.7	44.7	.61	.0653	1910	DD
2828	Denison clay	Corn	28.7	25.5	.79	.2267	1910	S
		June corn	7.3	16.2	.72	.0526	1910	DD
		Mustard	1.7	4.8			1910	DD
2948	Houston clay	Corn	13.5	10.0	1.63	.2200	1910	S
3341	Yazoo clay	Oats	8.4	13.2			1910'	D
		Corn	15.0	38.0	.54	.0810	1911	DD
3343	Crawford clay	Oats	9.0	19.8			1910	DD
		Corn	6.1	38.7	.80	.0488	1911	DD
	Average		14.12	24.8				
	Average (7)				.81	.1183		

TABLE 4.—Group 9. 0.161—.18% TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
334	Houston loam	Corn	16.0	30.1			1906	D
		Oats	7.5	8.5			1907	D
843	Wabash clay	Corn	19.0	16.1	1.44	.2746	1907	D
		Wheat	3.1	3 7			1908	S
		Corn	20.0	46.1	.43	.0860	1908	DD
		Mustard	2.7	2.6			1908	S
851	Wilson clay loam	Corn	20.8	23.4	1.36	.2829	1907	D
		Grass	4.2	4.5			1908	S
	Average		11.66	16.87				
	Average (3)				1.08	.2145		

TABLE 4. Group 10. 0.181—.20% TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
330	Crawford stony clay	Corn	10.1	19.8			1906	D
		Oats	6.5	6.9			1907	D
845	Sanders silt	Corn	30.0	29.2	1.39	.4170	1908	S
		Corn	8.2	8.0			1908	S
		Grass	4.6	9.9			1908	D
1929	Yazoo clay	Corn	15.3	32.9			1909	DD
2822	Sherman loam	Mustard	1.5	2.4			1909	D
		Corn	37.5	41.0			1910	D
	Average		14.2	18.75				
	Average (1)				1.39	.4170		

TABLE 4.—Group 11. 0.201—.22% TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
1927		Corn	36.25	30.25			1909	S

TABLE 4.—Group 12. 0.221—UP % TOTAL NITROGEN.

Laboratory No.	Name of soil.	Name of crop.	Weight of crop, grams.		Percentage of nitrogen in PK crop.	Grams nitrogen in crop.	Year.	Deficiency.
			PK	PNK				
1930	Yazoo clay subsoil	Corn	5.0	8.1			1909	D
		Sorghum	10.7	29.4			1909	DD
1133	Sharkey clay	Corn	18.7	14.8			1909	S
1935	Houston black clay	Corn	20.3	27.6			1909	D
1936	Houston black clay	Corn	26.4	32.1			1909	D
2946	Houston black clay	Corn	23.1	24.1	1.65	.3813	1910	S
1131	Wabash clay	Corn	32.0	47.8	.68	.2176	1908	D
		Mustard	6.5	13.2			1908	D
	Average		17.84	24.64				
	Average (2)				1.17	.2995		

SUMMARY AND CONCLUSIONS.

1. This bulletin contains the results of 332 pot experiments, to test the needs of soils for nitrogen.

2. There is a relation between the number of crops deficient in nitrogen in pot experiments, and the total nitrogen of the soil.

3. The weight of the crops increases with the nitrogen content of the soil up to .06 per cent., and remains nearly the same for the groups of soils containing .06—0.18 per cent. nitrogen.

4. The effect of fertilizer nitrogen in the pot experiments decreases as the percentage of nitrogen in the soil increases.

5. The average nitrogen content of the crops increases as the nitrogen content of the soil increases, but a larger number of crops should be studied with respect to this point.

6. The average nitrogen withdrawn by the crops in the pot experiments, expressed as bushels of corn per acre, increases from 8 bushels

for soils containing less than .02 per cent. nitrogen, to 56 bushels for soils containing 0.16—0.18 per cent. nitrogen.

7. It is difficult to establish percentages below which a soil is "deficient," and above which it is not, but the possibility of production can be related to the quantity of plant food in the soil, and other factors of production.